1 INTRODUCTION

1.1 Purpose of this Guidance

This document provides guidance on how to conduct the offsite consequence analyses for Risk Management Programs required under the Clean Air Act (CAA). Section 112(r)(7) of the CAA directed the U. S. Environmental Protection Agency (EPA) to issue regulations requiring facilities with large quantities of very hazardous chemicals to prepare and implement programs to prevent the accidental release of those chemicals and to mitigate the consequences of any releases that do occur. EPA issued that rule,"Chemical Accident Prevention Provisions" on June 20, 1996. The rule is codified at part 68 of Title 40 of the Code of Federal Regulations (CFR). If you handle, manufacture, use, or store any of the toxic or flammable substances listed in 40 CFR 68.130 above the specified threshold quantities in a process, you are required to develop and implement a risk management program under part 68 of 40 CFR. The rule applies to a wide variety of facilities that handle, manufacture, store, or use toxic substances, including chlorine and ammonia, and highly flammable substances, such as propane. If you are not sure whether you are subject to the rule, you should review the rule and Chapters 1 and 2 of EPA's *General Guidance for Risk Management Programs (40 CFR part 68),* available from EPA at http://www.epa.gov/ceppo/.

If you are subject to the rule, you are required to conduct an offsite consequence analysis to provide information to the state, local, and federal governments and the public about the potential consequences of an accidental chemical release. The offsite consequence analysis consists of two elements:

- A worst-case release scenario, and
- Alternative release scenarios.

To simplify the analysis and ensure comparability, EPA has defined the worst-case scenario as the release of the largest quantity of a regulated substance from a single vessel or process line failure that results in the greatest distance to an endpoint. In broad terms, the distance to the endpoint is the distance a toxic vapor cloud, heat from a fire, or blast waves from an explosion will travel before dissipating to the point that serious injuries from short-term exposures will no longer occur. Endpoints for regulated substances are specified in 40 CFR 68.22(a) and Appendix A of part 68 and are presented in Appendices B and C of this guidance.

Alternative release scenarios are scenarios that are more likely to occur than the worst-case scenario and that will reach an endpoint offsite, unless no such scenario exists. Within these two parameters, you have flexibility to choose alternative release scenarios that are appropriate for your site. The rule, in 40 CFR 68.28 (b)(2), and the *General Guidance for Risk Management Programs (40 CFR part 68)*, Chapter 4, provide examples of alternative release scenarios that you should consider when conducting the offsite consequence analysis.

RMP*Comp™

To assist those using this guidance, the National Oceanic and Atmospheric Administration (NOAA) and EPA have developed a software program, RMP*Comp™, that performs the calculations described in this document. This software can be downloaded from the EPA/CEPPO Internet website at http://www.epa.gov/ceppo/ds-epds.htm#comp.

This guidance document provides a simple methodology for conducting offsite consequence analyses. You may use simple equations to estimate release rates and reference tables to determine distances to the endpoint of concern. This guidance provides generic reference tables of distances, applicable to most of the regulated toxic substances, and chemical-specific tables for ammonia, chlorine, and sulfur dioxide. This guidance also provides reference tables of distances for consequences of fires and explosions of flammable substances. In some cases, the rule allows users of this document to adopt generic assumptions rather than the site-specific data required if another model is employed (see Exhibit 1).

The methodology and reference tables of distances presented here are optional. You are not required to use this guidance. You may use publicly available or proprietary air dispersion models to do your offsite consequence analysis, subject to certain conditions. If you choose to use models instead of this guidance, you should review the rule and Chapter 4 of the *General Guidance for Risk Management Programs*, which outline required conditions for use of models. In selected example analyses, this document presents the results of some models to provide a basis for comparison. It also indicates certain conditions of a release that may warrant more sophisticated modeling than is represented here. However, this guidance does not discuss the procedures to follow when using models; if you choose to use models, you should consult the appropriate references or instructions for those models.

This guidance provides distances to endpoints for toxic substances that range from 0.1 miles to 25 miles. Other models may not project distances this far (and some may project even longer distances). One commonly used model, ALOHA, has an artificial distance cutoff of 6 miles (i.e., any scenario which would result in an endpoint distance beyond 6 miles is reported as "greater than 6 miles"). Although you may use ALOHA if it is appropriate for the substance and scenario, you should consider choosing a different model if the scenario would normally result in an endpoint distance significantly greater than 6 miles. Otherwise, you should be prepared to explain the difference between your results and those in this guidance or other commonly used models. Also, you should be aware that the RMP*Submit system accepts only numerical entries (i.e., it will not accept a "greater than" distance). If you do enter a distance in RMP*Submit that is the result of a particular model's maximum distance cutoff (including the maximum distance cutoff in this guidance), you can explain this in the executive summary of your RMP.

Exhibit 1
Required Parameters for Modeling (40 CFR 68.22)

WORST CASE	ALTERNATIVE SCENARIO
Endpoints (§68.22(a))	
Endpoints for toxic substances are specified in part 68 Appendix A.	Endpoints for toxic substances are specified in part 68 Appendix A.
For flammable substances, endpoint is overpressure of 1 pound per square inch (psi) for vapor cloud explosions.	For flammable substances, endpoint is: ✦Overpressure of 1 psi for vapor cloud explosions, or ✦Radiant heat level of 5 kilowatts per square meter (kW/m^2) for 40 seconds for heat from fires (or equivalent dose), or ✦Lower flammability limit (LFL) as specified in NFPA documents or other generally recognized sources.
Wind speed/stability (§68.22(b))	
This guidance assumes 1.5 meters per second and F stability. For other models, use wind speed of 1.5 meters per second and F stability class unless you can demonstrate that local meteorological data applicable to the site show a higher minimum wind speed or less stable atmosphere at all times during the previous three years. If you can so demonstrate, these minimums may be used for site-specific modeling.	This guidance assumes wind speed of 3 meters per second and D stability. For other models, you must use typical meteorological conditions for your site.
Ambient temperature/humidity (§68.22(c))	
This guidance assumes 25°C (77°F) and 50 percent humidity. For other models for toxic substances, you must use the highest daily maximum temperature and average humidity for the site during the past three years.	This guidance assumes 25°C and 50 percent humidity. For other models, you may use average temperature/humidity data gathered at the site or at a local meteorological station.
Height of release (§68.22(d))	
For toxic substances, you must assume a ground level release.	This guidance assumes a ground-level release. For other models, release height may be determined by the release scenario.
Surface roughness (§68.22(e))	
Use urban (obstructed terrain) or rural (flat terrain) topography, as appropriate.	Use urban (obstructed terrain) or rural (flat terrain) topography, as appropriate.
Dense or neutrally buoyant gases (§68.22(f))	
Tables or models used for dispersion of regulated toxic substances must appropriately account for gas density. If you use this guidance, see Tables 1-4 for neutrally buoyant gases and Tables 5-8 for dense gases, or Tables 9-12 for specific chemicals.	Tables or models used for dispersion must appropriately account for gas density. If you use this guidance, see Tables 14-17 for neutrally buoyant gases and Tables 18-21 for dense gases, or Tables 22-25 for specific chemicals.
Temperature of released substance (§68.22(g))	
You must consider liquids (other than gases liquefied by refrigeration) to be released at the highest daily maximum temperature, from data for the previous three years, or at process temperature, whichever is higher. Assume gases liquefied by refrigeration at atmospheric pressure to be released at their boiling points. This guidance provides factors for estimation of release rates at 25°C or the boiling point of the released substance, and also provides temperature correction factors.	Substances may be considered to be released at a process or ambient temperature that is appropriate for the scenario. This guidance provides factors for estimation of release rates at 25°C or the boiling point of the released substance, and also provides temperature correction factors.

1.2 This Guidance Compared to Other Models

Results obtained using the methods in this document are expected to be conservative (i.e., they will generally, but not always, overestimate the distance to endpoints). The chemical-specific reference tables in this guidance provide less conservative results than the generic reference tables, because the chemical-specific tables were derived using more realistic assumptions and considering more factors.

Complex models that can account for many site-specific factors may give less conservative estimates of offsite consequences than the simple methods in this guidance. This is particularly true for alternative scenarios, for which EPA has not specified many assumptions. However, complex models may be expensive and require considerable expertise to use; this guidance is designed to be simple and straightforward. You will need to consider these tradeoffs in deciding how to carry out your required consequence analyses. Appendix A provides information on references for some other methods of analysis; these references do not include all models that you may use for these analyses. You will find that modeling results will sometimes vary considerably from model to model.

1.3 Number of Scenarios to Analyze

The number and type of analyses you must perform depend on the "Program" level of each of your processes. The rule defines three Program levels. Processes are eligible for Program 1 if, among other criteria, there are no public receptors within the distance to the endpoint for the worst-case scenario. Because no public receptors would be affected by the worst-case release, no further modeling is required for these processes. For processes subject to Program 2 or Program 3, both worst-case release scenarios and alternative release scenarios are required. To determine the Program level of your processes, consult 40 CFR 68.10(b), (c), and (d), or Chapter 2 of EPA's *General Guidance for Risk Management Programs (40 CFR part 68)*.

Once you have determined the Program level of your processes, you are required to conduct the following offsite consequence analyses:

- One worst-case release scenario for each Program 1 process;
- One worst-case release scenario to represent all regulated toxic substances in Program 2 and Program 3 processes;
- One worst-case release scenario to represent all regulated flammable substances in Program 2 and Program 3 processes;
- One alternative release scenario for each regulated toxic substance in Program 2 and Program 3 processes; and
- One alternative release scenario to represent all regulated flammable substances in Program 2 and Program 3 processes.

NOTE: You may need to analyze additional worst-case scenarios if release scenarios for regulated flammable or toxic substances from other covered processes at your facility would affect different public

receptors. For example, worst-case release scenarios for storage tanks at opposite ends of your facility may potentially reach different areas where people could be affected. In that case, you will have to conduct analyses of and report on both releases.

GUIDANCE FOR INDUSTRY-SPECIFIC RISK MANAGEMENT PROGRAMS

EPA developed guidance for industry-specific risk management programs for the following industries:

- Propane storage facilities
- Chemical distributors
- Waste water treatment plants
- Warehouses
- Ammonia refrigeration
- Small propane retailers & users

The industry-specific guidances are available from EPA at http://www.epa.gov/ceppo/.

Industry-specific guidances developed by EPA take the place of this guidance document and the *General Guidance for Risk Management Programs* for the industries addressed. If an industry-specific program exists for your process(es), you should use it as your basic guidance because it will provide more information that is specific to your process, including dispersion modeling.

1.4 Modeling Issues

The consequences of an accidental chemical release depend on the conditions of the release and the conditions at the site at the time of the release. This guidance provides reference tables of distances, based on results of modeling, for estimation of worst-case and alternative scenario consequence distances. Worst-case consequence distances obtained using these tables are not intended to be precise predictions of the exact distances that might be reached in the event of an actual accidental release. For this guidance, worst-case distances are based on modeling results assuming the combination of worst-case conditions required by the rule. This combination of conditions occurs rarely and is unlikely to persist for very long. To derive the alternative scenario distances, less conservative assumptions were used for modeling; these assumptions were chosen to represent more likely conditions than the worst-case assumptions. Nevertheless, in an actual accidental release, the conditions may be very different. Users of this guidance should remember that the results derived from the methods presented here are rough estimates of potential consequence distances. Other models may give different results; the same model also may give different results if different assumptions about release conditions and/or site conditions are used.

The reference tables of distances in this guidance provide results to a maximum distance of 25 miles. EPA recognizes that modeling results at such large distances are highly uncertain. Almost no experimental data or data from accidents are available at such large distances to compare to modeling results. Most data are reported for distances well under 10 miles. Modeling uncertainties are likely to increase as distances increase because conditions (e.g., atmospheric stability, wind speed, surface roughness) are not likely to remain constant over large distances. Thus, at large distances (e.g., greater than about 6 to 10 miles), the modeling results should be viewed as very coarse estimates of consequence distances. EPA believes,

however, that the results, even at large distances, can provide useful information for comparison purposes. For example, Local Emergency Planning Committees (LEPCs) and other local agencies can use relative differences in distance to aid in establishing chemical accident prevention and preparedness priorities among facilities in a community. Since worst-case scenario distances are based on modeling conditions that are unlikely to occur, and since modeling of any scenario that results in large distances is very uncertain, EPA strongly urges communities and industry not to rely on the results of worst-case modeling or any modeling that results in very large toxic endpoint distances in emergency planning and response activities. Results of alternative scenario models are apt to provide a more reasonable basis for planning and response.

1.5 Steps for Performing the Analysis

This Chapter presents the steps you should follow in using this guidance to carry out an offsite consequence analysis. Before carrying out one or more worst-case and/or alternative release analyses, you will need to obtain several pieces of information about the regulated substances you have, the area surrounding your site, and typical meteorological conditions:

- Determine whether each regulated substance is toxic or flammable, as indicated in the rule or Appendices B and C of this guidance.
- For the worst-case analysis, determine the quantity of each substance held in the largest single vessel or pipe.
- Collect information about any passive or active (alternative scenarios only) release mitigation measures that are in place for each substance.
- For toxic substances, determine whether the substance is stored as a gas, as a liquid, as a gas liquefied by refrigeration, or as a gas liquefied under pressure. For alternative scenarios involving a vapor cloud fire, you may also need this information for flammable substances.
- For toxic liquids, determine the highest daily maximum temperature of the liquid, based on data for the previous three years, or process temperature, whichever is higher.
- For toxic substances, determine whether the substance behaves as a dense or neutrally buoyant gas or vapor (see Appendix B, Exhibits B-1 and B-2). For alternative scenarios involving a vapor cloud fire, you will also need this information for flammable substances (see Appendix C, Exhibits C-2 and C-3).
- For toxic substances, determine whether the topography (surface roughness) of your site is either urban or rural as thse terms are defined by the rule (see 40 CFR 68.22(e)). For alternative scenarios involving a vapor cloud fire, you will also need this information for flammable substances.

After you have gathered the above information, you will need to take three steps (except for flammable worst-case releases):

(1) Select a scenario;

(2) Determine the release or volatilization rate; and
(3) Determine the distance to the endpoint.

For flammable worst-case scenarios, only steps one and three are needed. Sections 1.5.1 through 1.5.6 outline the procedures to perform the analyses. In addition to basic procedures, these sections provide references to sections of this guidance where you will find detailed instructions on carrying out the applicable portion of the analysis. Sections 1.5.1 through 1.5.3 below provide basic steps to analyze worst-case scenarios for toxic gases, toxic liquids, and flammable substances. Sections 1.5.4 through 1.5.6 provide basic steps for alternative scenario analysis. Appendix E of this document provides worksheets that may help you to perform the analyses.

1.5.1 Worst-Case Analysis for Toxic Gases

To conduct worst-case analyses for toxic gases, including toxic gases liquefied by pressurization (see Appendix E, Worksheet 1, for a worksheet that can be used in carrying out this analysis):

Step 1: Determine worst-case scenario. Identify the toxic gas, quantity, and worst-case release scenario, as defined by the rule (Chapter 2).

Step 2: Determine release rate. Estimate the release rate for the toxic gas, using the parameters required by the rule. This guidance provides methods for estimating the release rate for:

- Unmitigated releases (Section 3.1.1).
- Releases with passive mitigation (Section 3.1.2).

Step 3: Determine distance to endpoint. Estimate the worst-case consequence distance based on the release rate and toxic endpoint (defined by the rule) (Chapter 4). This guidance provides reference tables of distances (Reference Tables 1-12). Select the appropriate reference table based on the density of the released substance, the topography of your site, and the duration of the release (always 10 minutes for gas releases). Estimate distance to the endpoint from the appropriate table.

1.5.2 Worst-Case Analysis for Toxic Liquids

To conduct worst-case analyses for toxic substances that are liquids at ambient conditions or for toxic gases that are liquefied by refrigeration alone (see Appendix E, Worksheet 2, for a worksheet for this analysis):

Step 1: Determine worst-case scenario. Identify the toxic liquid, quantity, and worst-case release scenario, as defined by the rule (Chapter 2). To estimate the quantity of liquid released from piping, see Section 3.2.1.

Step 2: Determine release rate. Estimate the volatilization rate for the toxic liquid and the duration of the release, using the parameters required by the rule. This guidance provides methods for estimating the pool evaporation rate for:

- Gases liquefied by refrigeration alone (Sections 3.1.3 and 3.2.3).
- Unmitigated releases (Section 3.2.2).
- Releases with passive mitigation (Section 3.2.3).
- Releases at ambient or elevated temperature (Sections 3.2.2, 3.2.3, and 3.2.5).
- Releases of mixtures of toxic liquids (Section 3.2.4).
- Releases of common water solutions of regulated substances and of oleum (Section 3.3).

Step 3: Determine distance to endpoint. Estimate the worst-case consequence distance based on the release rate and toxic endpoint (defined by the rule) (Chapter 4). This guidance provides reference tables of distances (Reference Tables 1-12). Select the appropriate reference table based on the density of the released substance, the topography of your site, and the duration of the release. Estimate distance to the endpoint from the appropriate table.

1.5.3 Worst-Case Analysis for Flammable Substances

To conduct worst-case analyses for all regulated flammable substances (i.e., gases and liquids) (see Appendix E, Worksheet 3, for a worksheet for this analysis):

Step 1: Determine worst-case scenario. Identify the appropriate flammable substance, quantity, and worst-case scenario, as defined by the rule (Chapter 2).

Step 2: Determine distance to endpoint. Estimate the distance to the required overpressure endpoint of 1 psi for a vapor cloud explosion of the flammable substance, using the assumptions required by the rule (Chapter 5). This guidance provides a reference table of distances (Reference Table 13) for worst-case vapor cloud explosions. Estimate the distance to the endpoint from the quantity released and the table.

1.5.4 Alternative Scenario Analysis for Toxic Gases

To conduct alternative release scenario analyses for toxic gases, including toxic gases liquefied by pressurization (see Appendix E, Worksheet 4, for a worksheet for this analysis):

Step 1: Select alternative scenario. Choose an appropriate alternative release scenario for the toxic gas. This scenario should have the potential for offsite impacts unless no such scenario exists. (Chapter 6).

Step 2: Determine release rate. Estimate the release rate and duration of the release of the toxic gas, based on your scenario and site-specific conditions. This guidance provides methods for:

- Unmitigated releases (Section 7.1.1).
- Releases with active or passive mitigation (Section 7.1.2).

Step 3: Determine distance to endpoint. Estimate the alternative scenario distance based on the release rate and toxic endpoint (Chapter 8). This guidance provides reference tables of distances (Reference Tables 14-25) for alternative scenarios for toxic substances. Select the appropriate reference table based on the density of the released substance, the topography of your site, and the duration of the release. Estimate distance to the endpoint from the appropriate table.

1.5.5 Alternative Scenario Analysis for Toxic Liquids

To conduct alternative release scenario analyses for toxic substances that are liquids at ambient conditions or for toxic gases that are liquefied by refrigeration alone (see Appendix E, Worksheet 5, for a worksheet for this analysis):

Step 1: Select alternative scenario. Choose an appropriate alternative release scenario and release quantity for the toxic liquid. This scenario should have the potential for offsite impacts (Chapter 6), unless no such scenario exists.

Step 2: Determine release rate. Estimate the release rate and duration of the release of the toxic liquid, based on your scenario and site-specific conditions. This guidance provides methods to estimate the liquid release rate and quantity of liquid released for:

- Unmitigated liquid releases (Section 7.2.1).
- Mitigated liquid releases (Section 7.2.2).

The released liquid is assumed to form a pool. This guidance provides methods to estimate the pool evaporation rate and release duration for:

- Unmitigated releases (Section 7.2.3).
- Releases with passive or active mitigation (Section 7.2.3).
- Releases at ambient or elevated temperature (Sections 7.2.3).
- Releases of common water solutions of regulated substances and of oleum (Section 7.2.4).

Step 3: Determine distance to endpoint. Estimate the alternative scenario distance based on the release rate and toxic endpoint (Chapter 8). This guidance provides reference tables of distances (Reference Tables 14-25) for alternative scenarios for toxic substances. Select the appropriate reference table based on the density of the released substance, the topography of your site, and the duration of the release. Estimate distance to the endpoint from the appropriate table.

1.5.6 Alternative Scenario Analysis for Flammable Substances

To conduct alternative release scenario analyses for all regulated flammable substances (i.e., gases and liquids) (see Appendix E, Worksheet 6, for a worksheet for this analysis):

Step 1: Select alternative scenario. Identify the flammable substance, and choose the quantity and type of event for the alternative scenario consequence analysis (Chapter 6).

Step 2: Determine release rate. Estimate the release rate to air of the flammable gas or liquid, if the scenario involves a vapor cloud fire (Section 9.1 for flammable gases, Section 9.2 for flammable liquids).

Step 3: Determine distance to endpoint. Estimate the distance to the appropriate endpoint (defined by the rule). This guidance provides methods for:

- Vapor cloud fires (Section 10.1 and Reference Tables 26-29); select the appropriate reference table based on the density of the released substance and the topography of your site, and estimate distance to the endpoint from the appropriate table.
- Pool fires (Section 10.2); estimate distance from the equation and chemical-specific factors provided.
- BLEVEs (Section 10.3 and Reference Table 30); estimate distance from the quantity of flammable substance and the table.
- Vapor cloud explosions (Section 10.4 and Reference Table 13); estimate quantity in the cloud from the equation and chemical-specific factors provided, and estimate distance from the quantity, the table, and a factor provided for alternative scenarios.

1.6 Additional Sources of Information

EPA's risk management program requirements may be found at 40 CFR part 68. The relevant sections were published in the *Federal Register* on January 31, 1994 (59 FR 4478) and June 20, 1996 (61 FR 31667). Final rules amending the list of substances and thresholds were published on August 25, 1997 (62 FR 45130) and January 6, 1998 (63 FR 640). A consolidated copy of these regulations is available in Appendix F.

EPA is working with industry and local, state, and federal government agencies to assist sources in complying with these requirements. For more information, refer to the *General Guidance for Risk Management Programs* Appendix E (Technical Assistance). Appendices C and D of the *General Guidance* also provide points of contact for EPA and Occupational Safety and Health Administration (OSHA) at the state and federal levels for your questions. Your LEPC also can be a valuable resource.

Finally, if you have access to the Internet, EPA has made copies of the rules, fact sheets, and other related materials available at the home page of EPA's Chemical Emergency Preparedness and Prevention Office (http://www.epa.gov/ceppo/). Please check the site regularly, as additional materials are posted when they become available. If you do not have access to the Internet, you can call EPA's hotline at (800) 424-9346.